Validation of a Visual Perception Laboratory Using Field Data

by
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OBJECTIVE

The purpose of this test was to compare the human visual detection of military targets in the TARDEC Visual Perception laboratory (VPL) with human detection performance in the field. The data used were slides that were taken as part of a laser protection test. This is an example of dual-use data, a good way to save resources.

VPL PROCEDURAL SETUP

The test subjects were positioned in front of the rear projection screen in the car buck that we used for the first phase CRDA with GM. The Kodak Ekta-Pro slide projector was placed behind the screen.

The distance from the screen to the subject was 259cm. The AAV (Assault Amphibian Vehicle) in image 4-1 was used to check the distance from the projector to the screen. The actual length of the AAV is 7.943m and at a distance of 1 km, the vehicle is 0.0078 radians. With the subject to the screen distance of 259 cm, the AAV size was 2 cm high on the screen. The projector was placed so as to project the correct size of the AAV.

TESTING METHODOLOGY

Using the slide projector a total of 21 slides were arranged according to the field show number. The VPL was dimmed except the projector light and recording lamp light.

Subjects were instructed to point out the location of the target and name what type of vehicle he/she thought it was. Each slides was shown to the subjects with a 3 second time limit. If the subject wanted to proceed to the next slide within the time limit, the next image was shown.

Hard color copies of slides were prepared to record the subject responses. Each subject's response was recorded on the paper corresponding to each scene. The recording was done such that the position of the targets and the name of the targets that the subject pointed out were recorded.

SCORING METHOD

At the field location, the correct positioning of the target was considered an identification. In the VPL experiment, just pointing out the target and correctly naming the target was considered as identification. See appendix A for the scoring of individual responses.

	Field	LAB
ID	A target was considered identified if it was indicated in the correct position (grid square) and with the correct target name.	A target was considered identified if it was pointed out and named correctly.
DET	A target was considered detected if it was indicated in the correct position (grid square) but with the incorrect target name.	A target was considered detected if it was pointed out but named incorrectly.
UN	A target was considered undetected if it was not indicated at all.	A target was considered undetected if it was not pointed out at all.
FA	A target was considered a false alarm if it was indicated on the map, when actually, no target was there. An example of a FA is when sage brush, or bushes, are mistaken as vehicles.	A target was considered a false alarm if it was pointed out which is bush or junk pile actually.

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14. ABSTRACT
The purpose of this test was to compare the human visual dection of military targets in the TARDEC Visual Perception Laboratory (VPL) with human dectection performance in the field. The data used waere slides that were taken as part of a laser protection test. This is an example of dual0use data, a good way to save resources.

15. SUBJECT TERMS

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for a luminance plot. There were some images in which the target were located at the right or left edge of the slide. These may have been harder for the subjects to search.

DISTANCE definition

The target range was divided into bands of distance, each 300 meters deep. The entire target range was 3000 meters deep with the closest target at 600 meters and 500 meters wide. The distance variable is referred to as DIST-1 through DIST-8 and the specific ranges for each DIST are listed below.

DIST-1: 600 - 900 meters
DIST-2: 900 - 1200 meters
DIST-3: 1200 - 1500 meters
DIST-4: 1500 - 1800 meters
DIST-5: 1800 - 2100 meters
DIST-6: 2100 - 2400 meters
DIST-7: 2400 - 2700 meters
DIST-8: 2700 - 3000 meters

AVAILABLE DATA

The original primary purpose of the field test was to compare the performance of the laser eye protection systems (1). In the VPL, only the baseline, naked eye visual perception test was done. The ideal comparison is the naked eye (lens type x) field results with the VPL results.

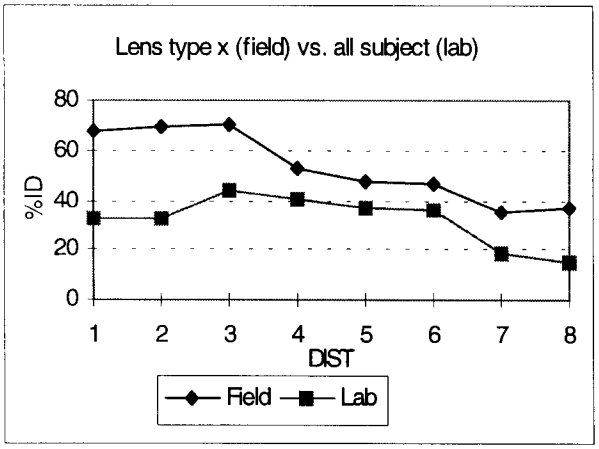
RESULTS

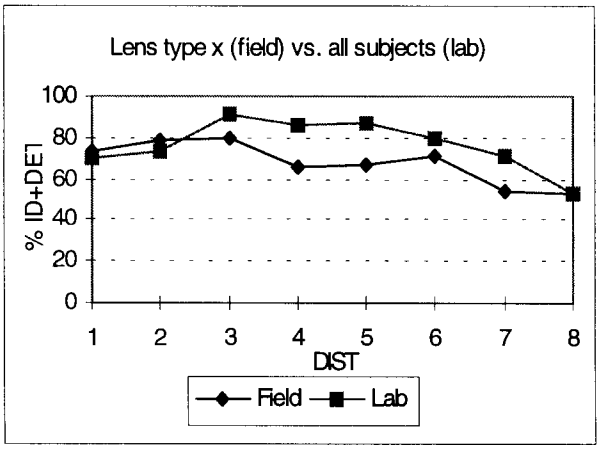
1) LAB DATA and NAKED EYE (Lens type X) result comparison

a) Lens X DIST for lens type x field test result vs. all subject lab data

Field	Lens		
Dist	%ID	%DET	%UN
1	67.4	5.8	26.8
2	69.2	9.1	21.7
3	70.5	9.4	20.1
4	53	12.8	34.2
5	47.7	19.5	32.9
6	46.3	24.8	28.9
7	35.3	19.3	45.3
8	37.1	16.1	46.9

LAB	All		
Dist	%ID	%DET	%UN
1	32.9	36.9	30.2
2	32.6	40.6	26.9
3	43.7	47.3	9.0
4	40.8	45.4	13.8
5	37.3	49.6	13.1
6	36.4	43.3	20.2
7	18.1	53.3	28.6
8	14.7	38.7	46.7





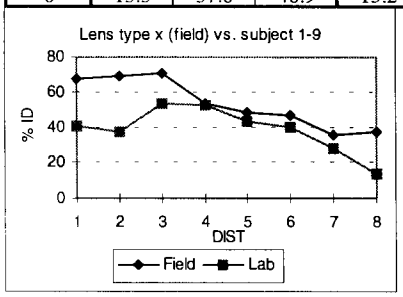
Correlation values
From dist-1 through dist-8: 0.67
From dist-3 through dist-8: 0.85

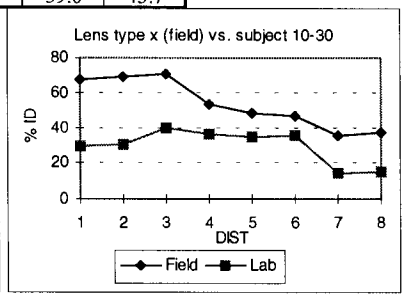
Correlation values
From dist-1 through dist-8: 0.58
From dist-3 through dist-8: 0.84

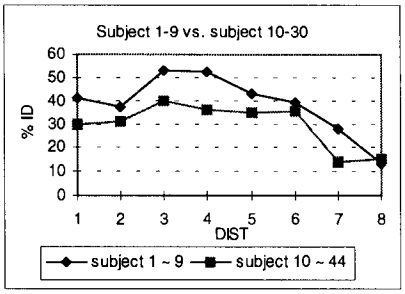
b) Lens X DIST for lens type x field test result vs. lab data separated by scene size

Subject response was divided according to the projector distance setup. Subject 1-9 saw smaller target size than the actual size but in brighter image than the second setup (subject 10 through 30).

Lab	subject 1 ~ 9			subject 10 ~ 44		
Dist	%ID	%DET	%UN	%ID	%DET	%UN
1	40.7	31.1	28.1	29.5	39.4	31.1
2	37.0	37.0	25.9	30.7	42.1	27.2
3	52.9	41.2	5.9	39.8	49.9	10.4
4	52.1	35.0	12.8	35.9	49.8	14.3
5	43.1	40.3	16.7	34.8	53.6	11.6
6	39.3	38.5	22.2	35.2	45.4	19.4
7	27.8	43.7	28.6	13.9	57.5	28.6
8	13.3	37.8	48.9	15.2	39.0	45.7





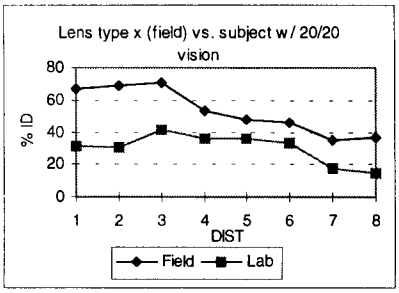


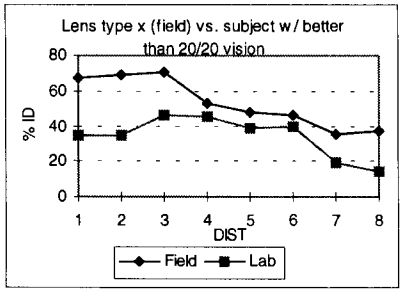
Correlation value of % ID	Subj. 1-9	Subj. 10-30
From dist-1 through dist-8:	0.64	0.66
From dist-3 through dist-8:	0.82	0.83

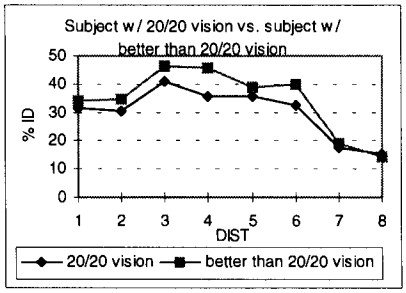
c) Lens X DIST for lens type x field test result vs. lab data separated by the 20/20 and higher vision

There are 15 subjects with 20/20 vision and 15 subjects with higher vision.

Lab	20/20 vision			better than 20/20 vision		
Dist	%ID	%DET	%UN	%ID	%DET	%UN
1	31.6	39.6	28.9	34.2	34.2	37.0
2	30.4	40.7	28.9	34.8	40.4	25.9
3	41.2	47.5	11.4	46.3	47.1	5.9
4	35.9	49.2	14.9	45.6	41.5	9.4
5	35.8	48.8	15.4	38.8	50.4	11.1
6	32.9	46.2	20.9	40.0	40.4	18.5
7	17.1	51.9	31.0	19.0	54.8	31.7
8	15.1	35.6	49.3	14.2	41.8	45.2



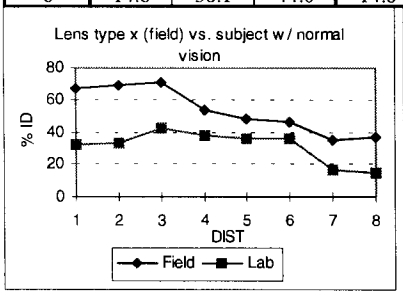


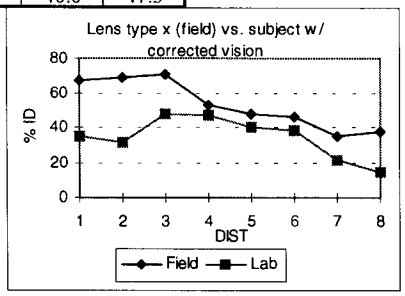


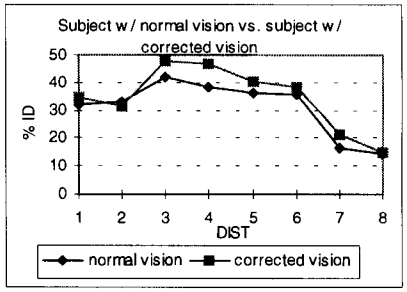
Correlation value of % ID	Subj. 20/20	Subj. better than 20/20
From dist-1 through dist-8:	0.7	0.64
From dist-3 through dist-8:	0.87	0.82

d) Lens X DIST for lens type x field test result vs. lab data separated by the normal and corrected vision
There are 22 subjects with normal vision and 8 subjects with corrected vision.

Lab	normal vision			corrected vision		
Dist	%ID	%DET	%UN	%ID	%DET	%UN
1	32.1	40.6	31.6	34.8	28.1	27.3
2	33.1	39.7	24.8	31.5	42.6	27.2
3	42.0	47.6	6.7	47.7	46.4	10.4
4	38.1	46.2	12.8	47.0	43.6	15.8
5	36.0	50.0	10.8	40.3	48.6	14.0
6	35.6	43.5	19.6	38.5	43.0	21.0
7	16.7	56.1	26.2	21.4	46.8	27.2
8	14.6	38.1	44.0	14.8	40.0	47.3



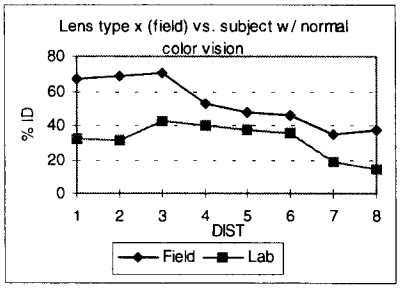


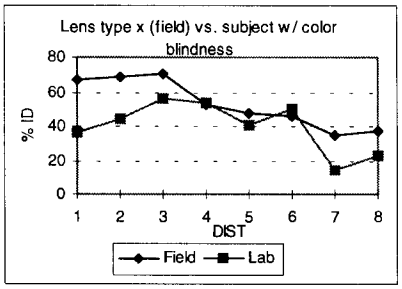


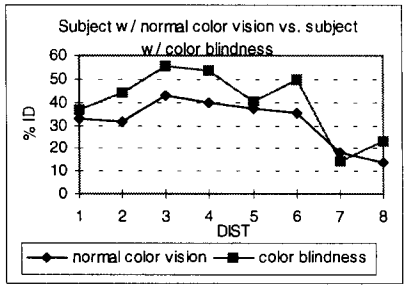
Correlation value of % ID	Subj. normal	Subj. corrected vision
From dist-1 through dist-8:	0.7	0.58
From dist-3 through dist-8:	0.85	0.84

e) Lens X DIST for lens type x field test result vs. lab data separated by the normal color and color blind
There are 28 subjects with normal color vision and 2 subjects with color blindness.

Lab	normal color vision			color blindness		
Dist	%ID	%DET	%UN	%ID	%DET	%UN
1	32.6	36.7	30.7	36.7	40.0	23.3
2	31.7	41.1	27.2	44.4	33.3	22.2
3	42.9	48.3	8.8	55.9	32.4	11.8
4	39.8	45.9	14.3	53.8	38.5	7.7
5	37.1	49.3	13.6	40.6	53.1	6.3
6	35.5	43.6	21.0	50.0	40.0	10.0
7	18.4	52.6	29.1	14.3	64.3	21.4
8	14.0	39.3	46.7	23.3	30.0	46.7







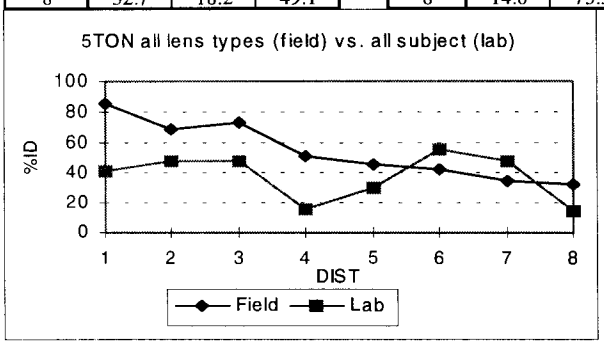
Correlation value of % ID	Subj. normal color	Subj. color blindness
From dist-1 through dist-8:	0.67	0.65
From dist-3 through dist-8:	0.84	0.84

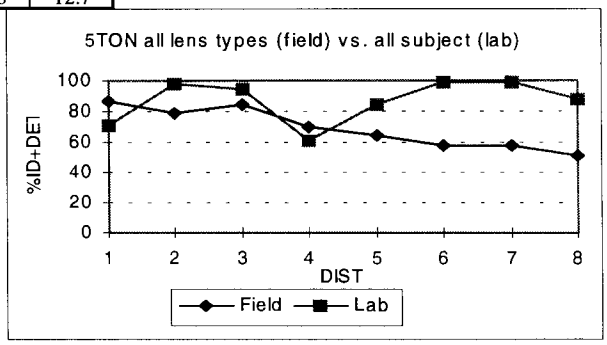
2) Target X DIST (for all lens types) vs. Lab data

5TON truck

5TON	Field		
Dist	%ID	%DET	%UN
1	85.1	1.2	13.7
2	69.3	10.1	20.6
3	73.2	10.7	16.1
4	51.4	18.1	30.6
5	45.7	18.3	36.0
6	41.8	16.4	41.8
7	34.8	23.2	42.0
8	32.7	18.2	49.1

5TON	Lab		
Dist	%ID	%DET	%UN
1	40.8	30.8	28.3
2	47.5	50.0	2.5
3	47.3	47.3	5.3
4	15.6	45.6	38.9
5	30.0	54.0	16.0
6	55.3	44.0	0.7
7	47.5	51.7	0.8
8	14.0	73.3	12.7



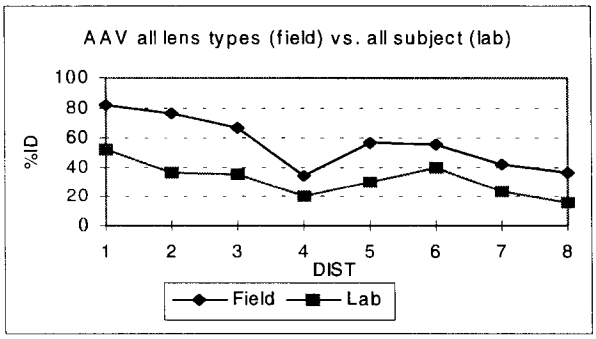


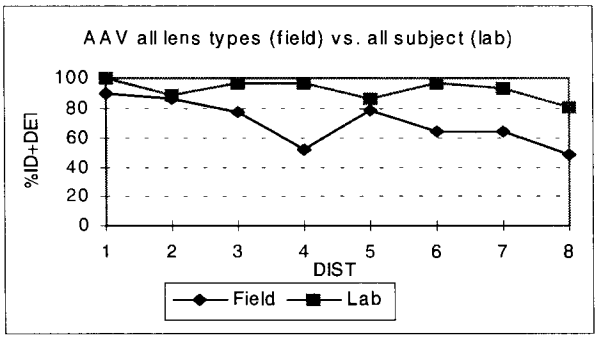
Correlation values: 0.3 -0.2

AAV

AAV	Field		
Dist	%ID	%DET	%UN
1	81.9	7.6	10.4
2	76.4	10.4	13.2
3	66.7	10.9	22.4
4	35.0	16.8	48.3
5	57.1	21.5	21.5
6	55.7	8.9	35.4
7	41.7	22.2	36.1
8	37.0	12.0	51.0

AAV	Lab		
Dist	%ID	%DET	%UN
1	52.2	47.8	0.0
2	36.7	52.2	11.1
3	35.6	61.1	3.3
4	20.0	76.7	3.3
5	30.0	56.7	13.3
6	40.0	56.7	3.3
7	23.3	70.0	6.7
8	15.6	65.6	18.9



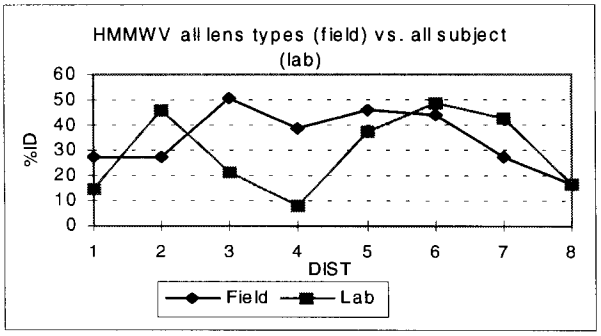


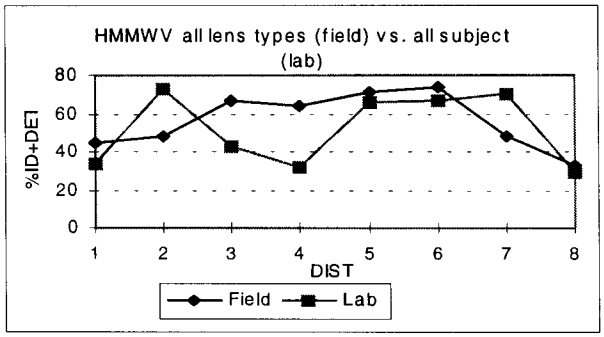
Correlation value: 0.9 0.3

HMMWV

HMMWV	Field		
Dist	%ID	%DET	%UN
1	27.4	16.7	56.0
2	27.1	20.5	52.4
3	50.9	15.5	33.6
4	38.6	25.6	35.8
5	45.8	25.3	28.9
6	43.8	30.1	26.2
7	27.2	21.2	51.6
8	16.4	16.4	67.2

HMMWV	Lab		
Dist	%ID	%DET	%UN
1	15.0	19.2	65.8
2	46.1	26.7	27.2
3	21.7	20.8	57.5
4	8.3	23.3	68.3
5	37.3	28.0	34.7
6	48.9	17.8	33.3
7	42.7	28.0	29.3
8	16.7	12.5	70.8





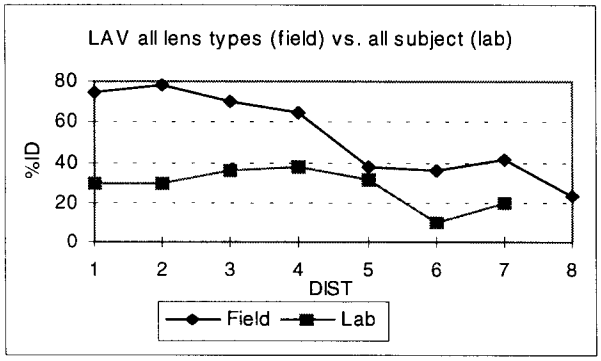
Correlation value: 0.1 0.3

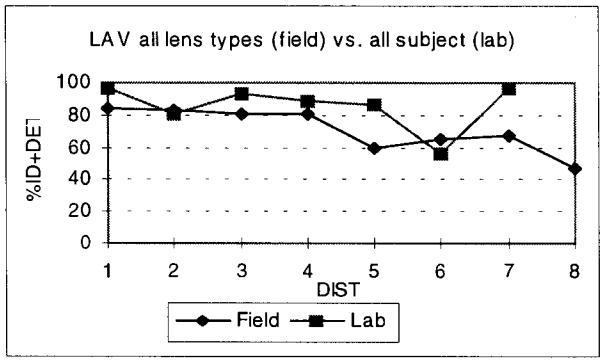
LAV

LAV	Field		
Dist	%ID	%DET	%UN
1	74.3	9.7	16.0
2	78.6	4.7	16.7
3	70.1	11.1	18.8
4	64.6	16.7	18.8
5	38.2	21.5	40.3
6	35.6	29.8	34.6
7	41.4	26.2	32.5
8	23.6	23.6	52.8

LAV	Lab		
Dist	%ID	%DET	%UN
1	30.0	66.7	3.3
2	30.0	50.8	19.2
3	35.6	57.8	6.7
4	37.5	50.8	11.7
5	31.7	55.0	13.3
6	10.0	46.7	43.3
7	20.0	76.7	3.3
8			

Empty data at distance 8 represents no data available from the lab.





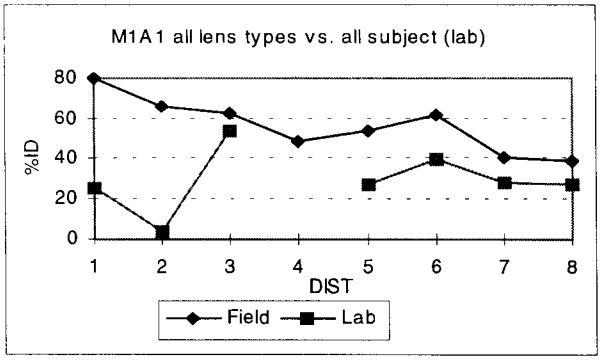
Correlation value: 0.6 0.4

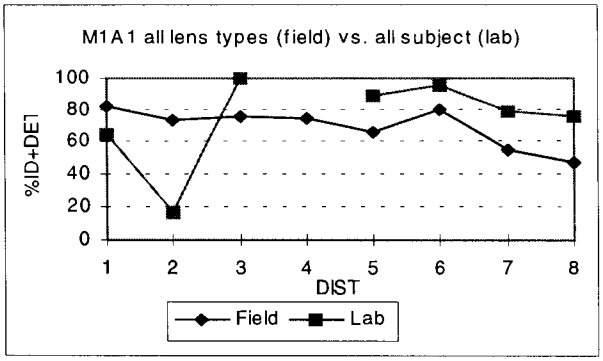
M1A1

M1A1	Field		
Dist	%ID	%DET	%UN
1	79.9	2.1	18.1
2	65.4	8.4	26.2
3	62.3	13.1	2.6
4	48.4	26.6	25.0
5	53.5	12.5	34.0
6	61.1	19.4	19.4
7	40.1	14.6	45.3
8	38.2	8.3	53.5

M1A1	Lab		
Dist	%ID	%DET	%UN
1	25.0	40.0	35.0
2	3.3	13.3	83.3
3	53.3	46.7	0.0
4			
5	26.7	62.2	11.1
6	38.9	56.7	4.4
7	27.5	50.8	21.7
8	26.7	48.9	24.4

Empty data set at distance 4 at the lab represents no data availability.



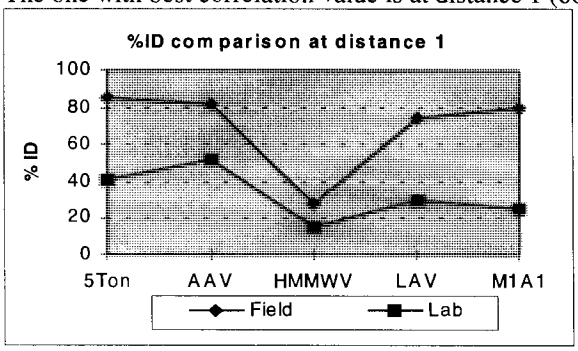


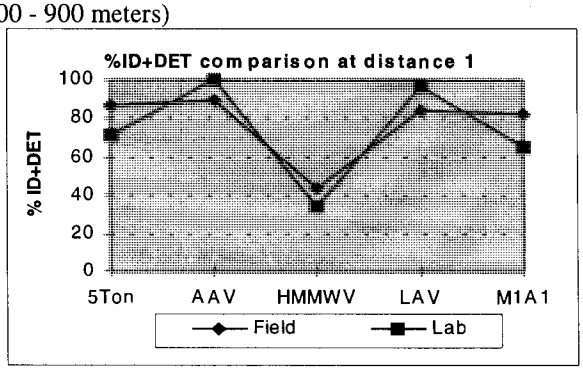
Correlation value: 0.0 0.0

3) Vehicle ID rate comparison at different distance

		% ID								%ID + DET							
		DIST								DIST							
	Target	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Field	5Ton	85.1	69.3	73.2	51.4	45.7	41.8	34.8	32.7	86.3	79.4	83.9	69.5	64.0	58.2	58.0	50.9
	AAV	81.9	76.4	66.7	35.0	57.1	55.7	41.7	37.0	89.5	86.8	77.6	51.8	78.6	64.6	63.9	49.0
	HMMWV	27.4	27.1	50.9	38.6	45.8	43.8	27.2	16.4	44.1	47.6	66.4	64.2	71.1	73.9	48.4	32.8
	LAV	74.3	78.6	70.1	64.6	38.2	35.6	41.4	23.6	84.0	83.3	81.2	81.3	59.7	65.4	67.6	47.2
	M1A1	79.9	65.4	62.3	48.4	53.5	61.1	40.1	38.2	82.0	73.8	75.4	75.0	66.0	80.5	54.7	46.5
Lab	5Ton	40.8	47.5	47.3	15.6	30.0	55.3	47.5	14.0	71.7	97.5	94.7	61.1	84.0	99.3	99.2	87.3
	AAV	52.2	36.7	35.6	20.0	30.0	40.0	23.3	15.6	100.0	88.9	96.7	96.7	86.7	96.7	93.3	81.1
	HMMWV	15.0	46.1	21.7	8.3	37.3	48.9	42.7	16.7	34.2	72.8	42.5	31.7	65.3	66.7	70.7	29.2
	LAV	30.0	30.0	35.6	37.5	31.7	10.0	20.0		96.7	80.8	93.3	88.3	86.7	56.7	96.7	
	M1A1	25.0	3.3	53.3		26.7	38.9	27.5	26.7	65.0	16.7	100.0		88.9	95.6	78.3	75.6
Correlation (field vs. lab)		0.7	-0.3	0.6	0.8	-0.4	0.3	-0.8	0.3	0.9	0.2	0.8	-0.1	-0.2	-0.1	0.8	1.0

The one with best correlation value is at distance 1 (600 - 900 meters)



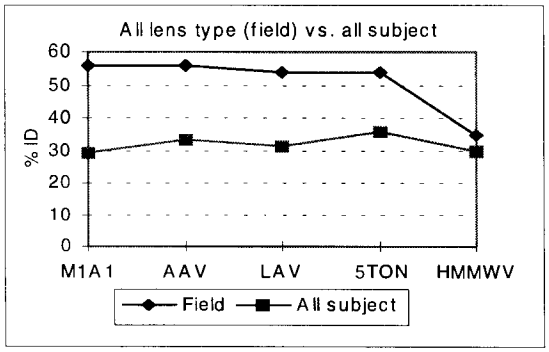


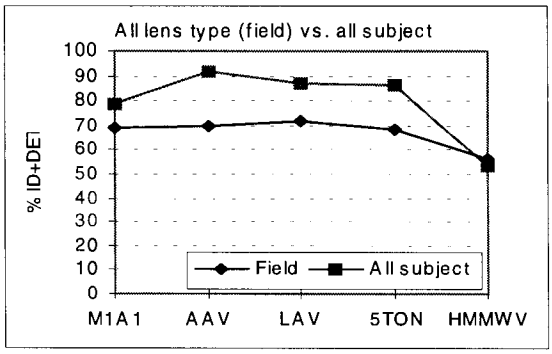
Correlation value: % ID - 0.7 %ID+DET - 0.9

5) ID rate comparison of different vehicles

a) Comparison with all subject data

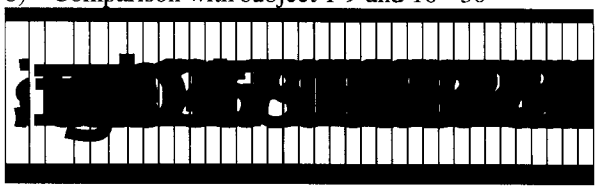
	Field			All subject		
Vehicle	%ID	%DET	%UN	%ID	%DET	%UN
M1A1	55.8	13.5	30.7	29.0	49.8	21.2
AAV	56.1	13.7	30.2	33.3	58.8	7.9
LAV	53.6	18.1	28.3	31.2	55.7	13.1
5TON	54.1	14.5	31.3	36.1	49.9	14.0
HMMWV	34.9	21.5	43.6	29.8	23.3	46.9

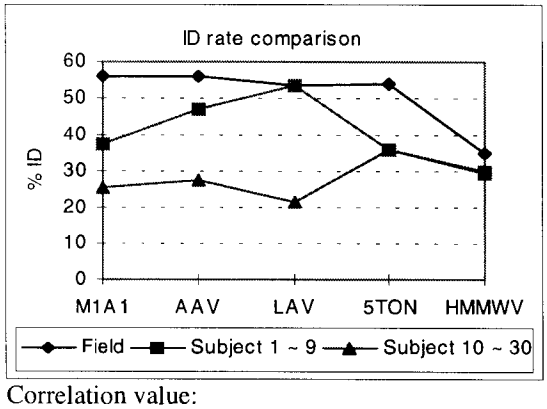


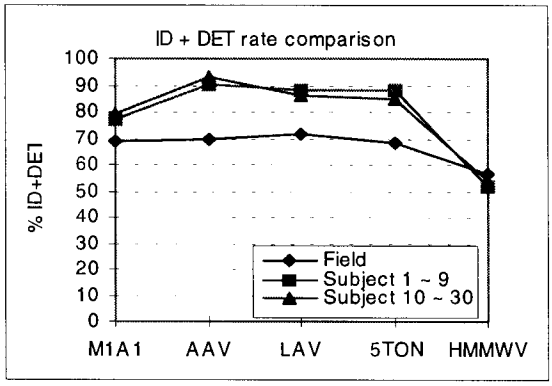


Correlation value: %ID only - 0.37 %ID + DET - 0.95

b) Comparison with subject 1-9 and 10 - 30



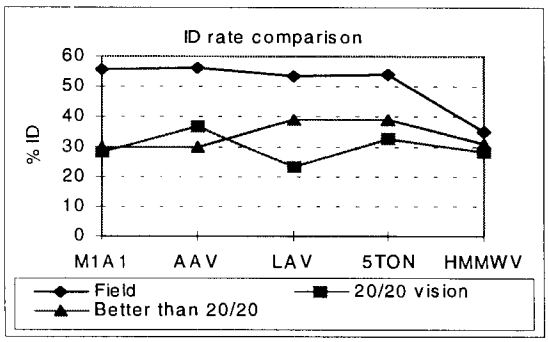


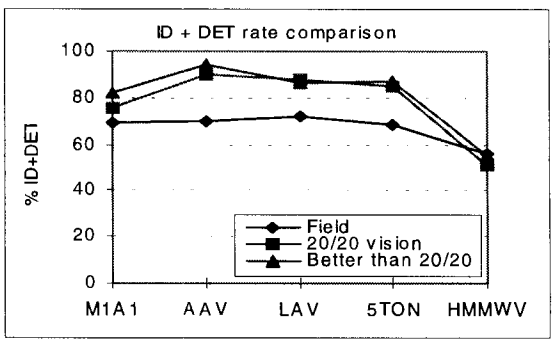


Correlation value:
Subj. 1 -9 : % ID - 0.61 %ID + DET - 0.95
Subj. 10 - 30 : % ID - 0.17 %ID + DET - 0.95

c) Comparison with 20/20 vision and better than 20/20 vision

	20/20 vision			Better than 20/20		
Vehicle	%ID	%DET	%UN	%ID	%DET	%UN
M1A1	28.2	47.5	24.3	29.8	52.2	18.0
AAV	36.7	52.9	10.4	30.0	64.6	5.4
LAV	23.5	63.9	12.5	38.8	47.5	13.7
5TON	33.0	52.1	14.9	39.1	47.7	13.2
HMMWV	28.6	22.5	49.0	31.0	24.2	44.8



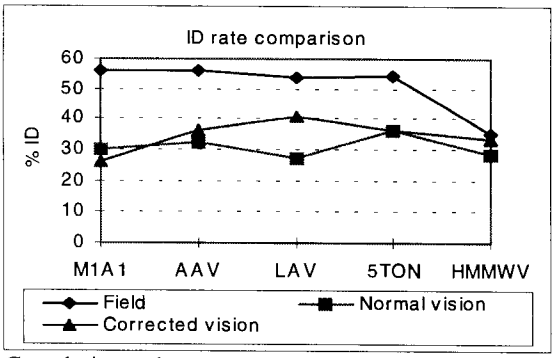


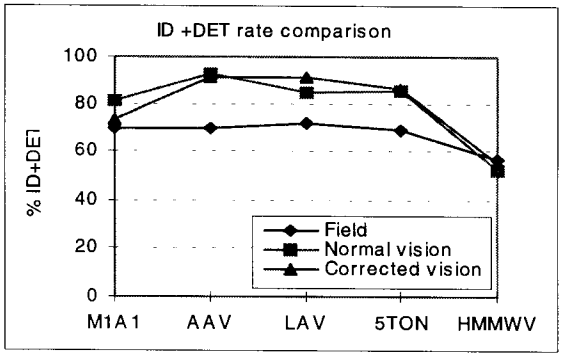
Correlation value:

Subj. 20/20 :	% ID - 0.23	%ID + DET - 0.95
Subj. better than 20/20 :	% ID - 0.21	%ID + DET - 0.94

d) Comparison with normal vision and corrected vision

	Normal vision			Corrected vision		
Vehicle	%ID	%DET	%UN	%ID	%DET	%UN
M1A1	30.3	51.0	18.8	26.1	47.1	26.8
AAV	32.1	60.4	7.4	36.1	54.9	9.0
LAV	27.2	57.7	15.1	40.5	51.0	8.5
5TON	36.1	49.6	14.3	36.0	50.6	13.5
HMMWV	28.2	24.1	47.8	33.7	21.6	44.8



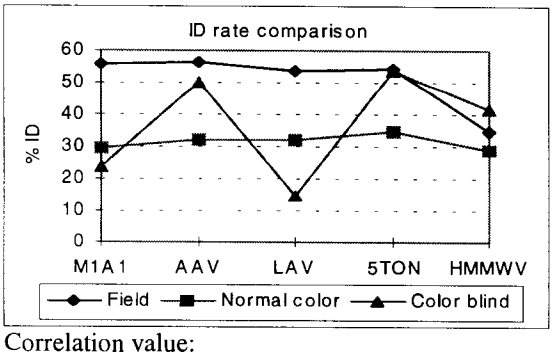


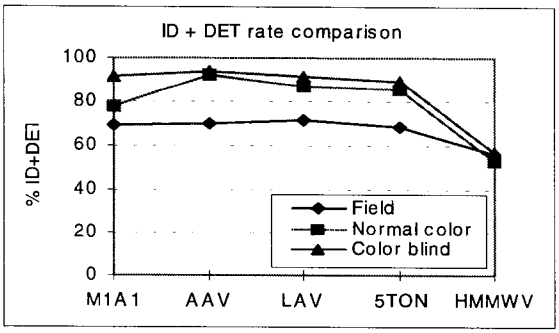
Correlation value:

Subj. normal vision :	% ID - 0.42	%ID + DET - 0.95
Subj. corrected vision :	% ID - 0.01	%ID + DET - 0.91

e) Comparison with normal color vision and color blindness
(note: only 2 data sets are available for the colorblind data)

	Normal color			Color blind		
Vehicle	%ID	%DET	%UN	%ID	%DET	%UN
M1A1	29.4	48.5	22.1	23.5	67.6	8.8
AAV	32.1	59.8	8.0	50.0	43.8	6.3
LAV	32.4	54.2	13.4	14.7	76.5	8.8
5TON	34.8	50.9	14.3	53.9	35.5	10.5
HMMWV	29.0	23.9	47.1	41.4	15.7	42.9





Correlation value:

Subj. normal color vision :	% ID - 0.54	%ID + DET - 0.94
Subj. color blindness:	% ID - -0.12	%ID + DET - 0.98

CONCLUSIONS

35mm color slides were used from another field test to help validate the overall test procedures used in the Visual Perception Laboratory (VPL). The color slides were of seven military vehicles positioned at tactical range in the desert. The correlation of the laboratory to the field ranged from 0.5 to 0.95 depending on the

variables analyzed and questions asked of the subjects. The highest correlation, 09.5, was obtained when comparing identification rates of the vehicles between the field and the lab. This is understandable in light of the fact that detection is strongly controlled by local luminance conditions, which are hard to replicate in the lab, and identification rates are more a function of the target size, shape, texture and target/background color differences, which are easily replicated in the lab using various projection techniques. Bottom line, the VPL can give results that correlate almost perfectly to the field if the correct questions are asked.

Overall, the lower luminance in the VPL of the projected image resulted in a lower identification rate and higher detection rate than the field test. This study shows that the vehicle identification rate aggregated by the distance gives the best correlation.

REFERENCE

1) Ground Laser Eye Protection System (GLEPS) for Armored Vehicle Crews test report, United States Marine Corps, Marine Corps Systems Command Quantico, VA. 22134-5080; January 25, 1994